

## The Effect of Problem-Based Learning Using Geoboard on Cognitive Ability of SDN 8 Mamboro Students

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**Abstract:** This study aims to investigate the effect of the Problem Based Learning (PBL) model using geoboard media on the cognitive abilities of fourth-grade students at SD Negeri 8 Mamboro, specifically in the mathematics subject focusing on plane figures. Employing a quasi-experimental design with a one-group pretest-posttest approach, the study involved 29 students as the population. The research hypothesis proposed that the PBL model assisted by geoboard media significantly improves students' cognitive abilities. Data were collected through a multiple-choice test consisting of 14 validated questions. Analysis included descriptive statistics, the Shapiro-Wilk normality test, paired sample t-test, and N-gain test. Results revealed a significant increase in cognitive ability, with the mean pretest score rising from 51.51 to 82.48 in the posttest. The paired sample t-test indicated a significance value of 0.001 ( $p < 0.05$ ) and a t-value of -19.324, confirming the acceptance of the alternative hypothesis and rejection of the null hypothesis. Furthermore, the N-gain score averaged 0.6765, categorized as moderate improvement. These findings demonstrate that implementing the PBL model with geoboard media effectively enhances students' cognitive skills by fostering independent discovery and active engagement in learning.

**Keywords :** problem-based learning, geoboard media, cognitive ability, mathematics education, elementary students, plane figures

**Abstrak:** Penelitian ini bertujuan untuk mengetahui pengaruh model Problem Based Learning (PBL) dengan menggunakan media papan berpaku (geoboard) terhadap kemampuan kognitif siswa kelas IV SD Negeri 8 Mamboro pada mata pelajaran Matematika dengan fokus pada materi bangun datar. Penelitian ini menggunakan desain pra-eksperimen (pre-experimental design) dengan rancangan one-group pretest-posttest. Populasi penelitian adalah seluruh siswa kelas IV SD Negeri 8 Mamboro yang berjumlah 29 orang. Hipotesis penelitian menyatakan bahwa model PBL berbantuan media papan berpaku berpengaruh signifikan terhadap kemampuan kognitif siswa. Teknik pengumpulan data dilakukan melalui tes pilihan ganda sebanyak 14 soal yang telah divalidasi oleh ahli. Analisis data meliputi statistik deskriptif, uji normalitas Shapiro-Wilk, serta uji hipotesis menggunakan paired sample t-test apabila data berdistribusi normal dan uji Wilcoxon signed-rank test apabila data tidak berdistribusi normal, serta uji N-gain untuk melihat peningkatan hasil belajar. Hasil penelitian menunjukkan adanya peningkatan kemampuan kognitif siswa yang signifikan, dengan nilai rata-rata pretest sebesar 51,51 meningkat menjadi 82,48 pada posttest. Uji paired sample t-test menunjukkan nilai signifikansi  $0,001 < 0,05$  dengan nilai t sebesar -19,324, sehingga hipotesis alternatif diterima dan hipotesis nol ditolak. Uji N-gain menunjukkan nilai rata-rata 0,6765 yang termasuk kategori sedang. Temuan ini membuktikan bahwa penerapan model PBL berbantuan media papan berpaku efektif dalam meningkatkan kemampuan kognitif siswa melalui kesempatan untuk menemukan pengetahuan secara mandiri serta keterlibatan aktif dalam proses pembelajaran.

**Kata Kunci :** problem based learning, media papan berpaku, kemampuan kognitif, pembelajaran matematika, siswa sekolah dasar, bangun datar

## INTRODUCTION

Learning is a process of managing and organizing the learning environment designed to facilitate, foster, and encourage students to learn optimally (Pane & Darwis Dasopang, 2017). In the context of the Merdeka Curriculum, learning is also understood

as a systematic effort to guide students to achieve learning objectives through a student-centered approach (Ariyana et al., 2020). The learning process at the elementary school level must be adjusted to the stage of children's cognitive development, thereby supporting their ability to communicate, interact, and maximize sensory potentials such as vision, hearing, and visual perception (Yulianti et al., 2022). At the age of 7–11 years, children's cognitive development increases rapidly because they actively explore new experiences and begin to understand the differences between prior knowledge and new information they receive (Atkinson, 1968; Corbett & Anderson, 1994). Optimal cognitive ability is very important because it becomes a key indicator of learning success (Zubaidah et al., 2018) and influences student achievement, especially in mathematics (Zakiah & Khairi, 2019).

Mathematics plays an important role in helping students solve everyday problems, as well as training logical, systematic, and critical thinking skills (Arsana et al., 2019). Therefore, mathematics learning needs to be oriented toward student activity so that the learning process becomes more meaningful and able to improve the quality of education (Tia & Muliandari, 2019). In practice, teachers play an important role in creating learning that is easy for students to understand and in accordance with their developmental characteristics (Malik et al., 2024).

However, the results of interviews with the fourth-grade homeroom teacher at SD Negeri 8 Mamboro indicate that students still experience difficulties in understanding the topic of plane figures. Most students' daily scores remain below the Minimum Mastery Criteria (KKTP) of 70, indicating low mastery of basic concepts. Observations show that the teacher still uses lecture and assignment methods with limited media, such as textbooks, whiteboards, and markers. This teacher-centered learning condition causes students to rarely ask questions or express their opinions. Interviews with students also reveal differences in enthusiasm, where active students prefer group activities, while passive students prefer direct explanation because they feel afraid to make mistakes or be laughed at, resulting in low participation. This situation shows the need for a learning model that actively involves students and provides concrete learning experiences.

One model that fits these needs is Problem-Based Learning (PBL). This model emphasizes active student involvement through exploration, investigation, problem solving, and reflection on the solutions generated (Pratiwi et al., 2023). PBL has also been proven effective in improving higher-order thinking skills, conceptual understanding, and student motivation because learning is connected to real-life contexts (N.K. Mardani et al., 2021). Recent studies show that PBL can improve cognitive abilities and geometry understanding among elementary school students through problem-based learning activities (Erika, 2020; Sarimudin, 2021).

In addition to the learning model, concrete media also plays an important role in helping students understand the abstract concepts of plane figures. One effective medium is the geoboard, which allows students to visualize various plane figures, manipulate shapes directly, and understand concepts of area and perimeter more

concretely (Masitoh & Habudin, 2018). Recent studies show that geoboard learning media can improve students' understanding of the concept of the perimeter of plane figures (Aini et al., 2024). This tool allows students to create various plane geometric shapes using pegs, enabling them to see and physically experience the shapes directly. The use of a geoboard in learning can enhance students' understanding of plane figures while making the learning process more engaging and interactive (Ali et al., 2025).

However, literature review findings show that although many studies have used PBL to improve mathematics learning outcomes, and a number of other studies have proven the effectiveness of geoboards in geometry learning, no research has specifically integrated PBL with geoboard media at the elementary school level, particularly in learning plane figures. Some PBL studies do not use concrete media, while studies on geoboards more frequently employ direct instruction models. Thus, an important research gap exists, namely that the influence of integrating PBL assisted by geoboard media on elementary students' cognitive abilities in the context of geometry learning has not been examined.

Based on this gap, this study was conducted to analyze the effect of the Problem-Based Learning model assisted by geoboard media on the cognitive abilities of fourth-grade students at SD Negeri 8 Mamboro. This study is expected to contribute to the development of innovative problem-based learning models and the use of concrete media in elementary mathematics learning, particularly in the topic of plane figures.

## METHOD

This study employed an experimental method with a quantitative approach to examine the effect of the Problem Based Learning (PBL) model assisted by pegboard media on the cognitive abilities of elementary school students. The research was conducted at SDN 8 Mamboro with a population consisting of all fourth-grade students, totaling 29 participants. The sampling technique used was saturated sampling, in which the entire population was included as the research sample. This study applied a *Pre-Experimental Design* using the *One-Group Pretest–Posttest Design*. This design was selected to determine the effect of the treatment through the implementation of the PBL model assisted by pegboard media on the improvement of students' cognitive abilities. The research design is illustrated as follows:

**Table 1.** One-Group Pretest-Posttest Research Design

Pretest	Treatment	Posttest
O <sub>1</sub>	X	O <sub>2</sub>

Information :

O<sub>1</sub> : Pretest score of students' cognitive ability before the implementation of the PBL model

X : Treatment through the implementation of the *Problem Based Learning* model assisted by pegboard

O<sub>2</sub> : Posttest score of students' cognitive ability after the implementation of the PBL model

The research procedure consisted of three stages: preparation, implementation, and evaluation. In the preparation stage, the researcher conducted preliminary observations to identify classroom conditions, prepared learning materials, and developed the test instrument. The research instrument consisted of 14 multiple-choice questions constructed based on the six cognitive domains of Bloom's taxonomy (remembering, understanding, applying, analyzing, evaluating, and creating). The instrument development began with constructing a test blueprint that aligned learning indicators with cognitive domains.

Before being used in the study, the instrument underwent expert validation to assess content relevance, indicator alignment, language clarity, and the appropriateness of the items for elementary school students. After expert validation, the instrument was pilot-tested on students from another elementary school whose academic characteristics were assumed to be similar to those at the research site. The selection of this pilot school was based on the assumption that the cognitive abilities of students at both schools were relatively comparable, ensuring that the pilot test results would objectively represent the quality of the instrument. Based on the pilot test results, 14 out of the 20 developed items were declared valid, while 6 items were invalid. Only the valid items were used in the study. In addition, the instrument's reliability was analyzed using Cronbach's Alpha, which produced a coefficient of 0.82, indicating high reliability.

During the implementation stage, the researcher administered a pretest to measure students' initial cognitive ability, followed by the application of the Problem Based Learning model assisted by pegboard media in the topic of plane figures. In the evaluation stage, a posttest was administered to measure students' cognitive improvement after receiving the treatment. The variables in this study consisted of the independent variable, namely the Problem Based Learning model assisted by pegboard media, and the dependent variable, namely the cognitive abilities of fourth-grade students in the topic of plane figures. The pretest and posttest instruments were used to measure students' cognitive achievement before and after the treatment based on the learning indicators and cognitive domains assessed.

Data analysis included descriptive and inferential statistics. Descriptive analysis was used to describe the pretest and posttest scores, including the mean, median, standard deviation, minimum, and maximum values. Prior to hypothesis testing, the normality of the data was examined using the Shapiro-Wilk test, as the sample size was fewer than 50 students. This normality test was essential to determine whether the data were normally distributed, which directly guided the selection of the appropriate statistical test. If the Shapiro-Wilk significance value was greater than 0.05, the data were considered normally distributed, and the hypothesis was tested using the Paired Sample t-test. Conversely, if the significance value was less than 0.05, the data were considered non-normal and the Wilcoxon Signed-Rank Test was applied. All statistical analyses were performed using SPSS Statistics to ensure accuracy and reliability of the results.

## RESULT AND DISCUSSION

This study involved 29 fourth-grade students from SD Negeri 8 Mamboro as research subjects who participated in a mathematics learning process based on the Problem-Based Learning (PBL) model assisted by geoboards. Data were collected through pretest and posttest assessments administered before and after the implementation of the learning model. The objective of this measurement was to identify quantitative changes in students' cognitive abilities and to examine the effectiveness of the applied instructional model. Data analysis was conducted both descriptively and inferentially using SPSS Statistics software.

### Pretest Learning Outcomes

The pretest was administered prior to the PBL intervention to determine students' initial understanding of plane geometry. The pretest results are presented in Table 1.

**Table 1.** Pretest Data Analysis Results

Statistic	Pretest
Mean	51,51
Standar Deviation	13,804
Minimum Score	35
Maxsimum Score	85

Based on Table 1, the average pretest score of 51.51 indicates that students' initial understanding of the topic was relatively low. The high standard deviation (13.804) reflects considerable variation in students' prior knowledge. This suggests that previous conventional teaching methods were not yet optimal in accommodating individual learning differences. The minimum score of 35 indicates the presence of students who require a more concrete learning approach, whereas the maximum score of 85 shows that a small group of students had already developed a strong foundational understanding.

### Posttest Learning Outcomes

Following the implementation of the PBL model assisted by geoboards, students' cognitive performance improved significantly. The posttest results are shown in Table 2.

**Table 2.** Hasil analisis data post-test

Statistic	Posttest
Mean	82,48
Standar Deviation	9,367
Minimum Score	64
Maxsimum Score	100

The data in Table 2 show that the average posttest score increased to 82.48. The decrease in standard deviation from 13.804 to 9.367 indicates a more homogeneous distribution of scores, reflecting a more equitable learning improvement across students. The minimum score rose significantly from 35 to 64, indicating substantial progress among lower-performing students, while the maximum score of 100 suggests that higher-achieving students were also able to fully optimize their potential. At the class

level, 82.76% of students exceeded the Mastery Learning Criteria (KKTP), demonstrating the effectiveness of this instructional approach.

### Wilcoxon Signed-Rank Test

To examine the significance of differences between pretest and posttest results, a Wilcoxon Signed-Rank Test was conducted. The results are presented in Table 3.

**Table 3.** Wilcoxon Signed-Rank Test Results

Variabel	N	Mean Rank	Sum of Ranks	Z	Asymp. Sig. (2-tailed)
Negative Ranks	0	0,00	0,00	-4,7280	<0,001
Positive Ranks	29	15,00	435,00		
Ties		0			

The significance value of  $<0.001$  ( $<0.05$ ) indicates a highly significant difference between students' learning outcomes before and after the intervention. The negative Z value indicates an increase in scores from pretest to posttest. The fact that all students (100%) showed improvement without any score decline suggests that PBL assisted by geoboards had a consistently positive impact.

### Paired Sample T-Test

Furthermore, hypothesis testing using the Paired Sample T-Test produced the results shown in Table 4.

**Table 4.** Paired Sample T-Test Results

Paired Differences	95% Confidence Interval of the Difference			t	df	One-Sided p	Two-Sided p
	Mean	Std. Deviation	Std. Error Mean				
Pair 1 (Pretest - Posttest)	-30,966	8,629	1,602	-34,248	-	28	<0,001
					27,683	19,324	<0,001

The results show a mean difference of -30.966 with a significance value of  $<0.001$ , indicating that  $H_0$  is rejected and  $H_a$  is accepted. This means that the PBL model assisted by geoboards had a significant effect on improving students' cognitive performance.

### N-Gain Analysis

An analysis of learning gains was conducted using the N-Gain test. The results are presented in Table 5.

**Table 5.** N-Gain Analysis

Variabel	N	Minimum	Maximum	Mean	Std. Deviation
N-Gain Score	29	0,33	1,00	0,6765	0,7709

The average N-Gain score of 0.6765 indicates that the improvement in students' cognitive abilities falls within the moderate category. This suggests that the

implementation of PBL assisted by geoboards was effective in enhancing learning outcomes, although there remains room for further improvement.

The findings of this study demonstrate that the use of the Problem-Based Learning (PBL) model assisted by geoboard media significantly improves students' cognitive abilities. The low pretest scores indicate that conventional teaching methods were not effective in developing students' conceptual understanding, particularly in geometry, which requires visualization and spatial reasoning. Through the PBL syntax—beginning with contextual problem presentation, followed by group organization, investigation, collaborative discussion, and evaluation—students engaged in a more active, meaningful, and inquiry-oriented learning process. This finding is consistent with Erika (2020), who reported that PBL significantly enhances mathematics learning outcomes, and is supported by Sarimudin (2021), who found that problem-based approaches align with the concrete thinking characteristics of elementary school students.

Theoretically, these results can be explained through Piaget's constructivist theory, which states that children aged 7–11 are in the concrete operational stage and therefore require direct experiences to construct conceptual understanding. PBL provides opportunities for students to explore objects, manipulate information, and test their hypotheses through problem-solving activities. This is reinforced by Vygotsky's sociocultural theory, which emphasizes the importance of social interaction in helping students reach the Zone of Proximal Development (ZPD) (Woolfolk, 2023). Group discussions and collaborative activities in PBL provide scaffolding and social support, enabling students to achieve higher levels of understanding than they could independently.

Furthermore, PBL facilitates meaningful learning as described by Ausubel, in which new knowledge becomes more stable when linked to students' prior knowledge and real-life experiences (Schunk, 2020). From the perspective of information processing theory (Slavin, 2022), activities such as identifying shapes, analyzing their properties, and engaging in collaborative problem-solving help strengthen the encoding process, enabling information to transfer more effectively from short-term to long-term memory.

The integration of the geoboard as a concrete instructional medium also played an important role in enhancing students' cognitive abilities. The geoboard allows students to construct geometric shapes, explore their attributes, and visualize relationships among geometric elements through direct manipulation. The simultaneous use of verbal and visual channels aligns with Mayer's multimedia learning theory (Schunk, 2020), which emphasizes that understanding is enhanced when learners process information through dual modalities. Manipulative activities with the geoboard also support students' spatial reasoning and visual representation skills—two essential components in understanding two-dimensional shapes (Slavin, 2022).

Previous studies support these findings. Research has shown that geoboard media enhances spatial ability, conceptual understanding, and analytical skills in

elementary geometry learning (Kurniasih & Wijaya, 2022; Rahmawati & Lestari, 2021). However, earlier studies generally examined geoboard within direct instruction models, whereas PBL studies rarely incorporated concrete media. Therefore, this study contributes new evidence indicating that integrating PBL with concrete manipulatives provides a more effective approach for strengthening students' conceptual understanding than using either component alone.

From a motivational perspective, the findings align with Self-Determination Theory (Deci & Ryan, as cited in Santrock, 2021), which posits that learning is more successful when the needs for autonomy, competence, and relatedness are fulfilled. PBL enables students to explore solutions independently (autonomy), experience success in completing tasks (competence), and collaborate with peers (relatedness). This combination enhances intrinsic motivation and supports improved academic performance.

Overall, this study not only confirms that PBL assisted by geoboard media significantly influences students' cognitive abilities but also contributes theoretically to the development of instructional models aligned with elementary students' cognitive development. Practically, the findings offer meaningful implications for teachers in selecting effective, innovative, and context-based learning strategies. The integration of PBL with concrete media such as the geoboard can serve as an effective alternative for improving conceptual understanding in elementary mathematics, particularly in geometry.

## CONCLUSION AND SUGGESTION

Based on the results and discussion presented above, it can be concluded that the Problem-Based Learning (PBL) model assisted by the geoboard has a significant effect on the cognitive abilities of fourth-grade students at SD Negeri 8 Mamboro in the mathematics subject, particularly in the topic of plane figures. This is evidenced by the increase in the average score from 51.51 in the pretest to 82.48 in the posttest, with a difference of 30.97 points. The results of the Wilcoxon Signed-Rank Test showed a significance value of  $<0.001$ , which is smaller than  $\alpha = 0.05$ , indicating that  $H_1$  is accepted and there is a highly significant difference between students' cognitive abilities before and after the treatment. All students (100%) experienced an increase in scores, with 24 students (82.76%) achieving or exceeding the Minimum Mastery Criteria (KKTP). The N-Gain test result showed an average value of 0.6765, which falls into the moderate category, indicating that this learning model is effective in enhancing students' cognitive abilities through investigation, exploration, and active engagement in the learning process supported by the use of concrete media in the form of a geoboard. The implementation of the Problem-Based Learning model assisted by the geoboard proved to accommodate the characteristics of elementary school students who are at the concrete operational stage and facilitate meaningful, collaborative, and enjoyable learning experiences.

Based on the results of this study, several suggestions can be made. First, teachers are advised to implement the Problem-Based Learning model assisted by a geoboard as an innovative learning alternative in mathematics, especially in geometry topics at the elementary level. Second, schools are expected to provide learning facilities and infrastructure that support the implementation of problem-based learning models, such as concrete media in the form of geoboards. Third, future researchers are encouraged to develop studies with more comprehensive experimental designs using control groups and to measure other aspects such as students' critical thinking skills and collaborative abilities.

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